(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 616 074 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 94104326.7

(22) Date of filing: 18.03.94

(51) Int. Cl.5: D21F 11/00

(30) Priority: 18.03.93 US 32908

(43) Date of publication of application: 21.09.94 Bulletin 94/38

(84) Designated Contracting States: BE DE ES FR GB IT NL SE

(71) Applicant: KIMBERLY-CLARK CORPORATION
401 North Lake Street
Neenah, Wisconsin 54956-0349 (US)

(72) Inventor: Hermans, Michael Alan
1154 Park Village Drive
Neenah, Wisconsin 54956 (US)
Inventor: Chen, Fung-jou
3216 White Birch Lane
Appleton, Wisconsin 54915 (US)
Inventor: Kressner, Bernhardt Edward
531 North Bateman
Appleton, Wisconsin 54911 (US)

(74) Representative: Diehl, Hermann, Dr. Dipl.-Phys. et al
DIEHL, GLÄSER, HILTL & PARTNER
Patentanwälte
Flüggenstrasse 13
D-80639 München (DE)

(54) **Paper sheet or towel and method of making same.**

(57) A paper sheet, especially suitable for use as a household paper towel, can be made using a modified wet pressing process by adding a wet strength resin to the papermaking fibers and, after initially forming the wet web, conforming the wet web to the surface contour of a relatively coarse fabric to give the web a textured surface. The web is dried to substantially preserve its texture and thereafter creped. The resulting web has an exceptionally high degree of bulk and absorbency not previously attained by non-throughdried paper products.

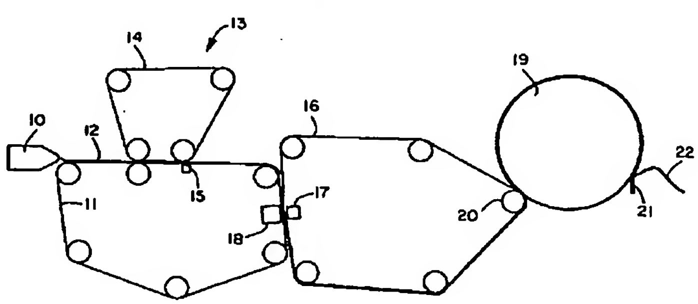

FIG. 1

EP 0 616 074 A1

In the manufacture of paper products such as paper towels, dinner napkins, tissue and the like, there are generally two different methods of making basesheets for these various products. One method is commonly referred to as wet-pressing and the other is referred to as throughdrying. While the two methods may be the same at the front end and the back end of the process, they differ primarily in the manner in which water is removed from the wet web after its initial formation.

For example, in the wet-pressing method, which is the older and more conventional method of making paper towels, the newly-formed wet web is typically transferred onto a papermaking felt and thereafter pressed against the surface of a steam-heated Yankee dryer while it is still supported by the felt. As the web is transferred to the surface of the Yankee, water is expressed from the web and is absorbed by the felt. The dewatered web, typically having a consistency of about 40 percent, is then dried while on the hot surface of the Yankee. The web is then creped to soften it and provide stretch to the resulting sheet. A disadvantage of wet pressing is that the pressing step densifies the web, thereby decreasing the bulk and absorbency of the sheet, which must be restored by the subsequent creping step.

In the throughdrying method, which has become more common in recent years, the newly-formed web is transferred to a relatively porous fabric and non-compressively dried by passing hot air through the web. The resulting web can then be transferred to a Yankee dryer for creping. Because the web is substantially dry when transferred to the Yankee, the density of the web is not significantly reduced by the transfer. Also, by drying the web while supported on the throug hdrying fabric, a less dense sheet is produced in the first place. This results in a more bulky and absorbent sheet. However, a disadvantage of throughdrying is the operational energy costs and the capital costs associated with the throughdryers.

Because there are many existing wet-pressing paper machines making paper towels and the like, and because there is a continuing desire to improve the bulk and absorbency of such products, there is a need for a means of producing paper towels having throughdried characteristics using existing wet-pressing paper machines without the expense of adding new throughdryers.

This object is solved by the paper sheet of independent claim 1 or 20, the paper towel of independent claim 7 or 21 and the method of independent claim 9. Further advantageous features, aspects and details of the invention are evident from the dependent claims, the description, examples and drawings. The claims are intended to be understood as a first non-limiting approach of defining the invention in general terms.

The invention provides a method for making paper sheets having high bulk and absorbency.

The invention is based on Applicant's findings that a wet-pressed product can be made having bulk and absorbency properties equivalent to those of comparable throughdried products. More particularly, wet-pressed paper towels can be made by incorporating a wet strength resin into the furnish and substituting a "molding" fabric for the conventional wet-pressing felt in order to impart more contour or 3-dimensionality to the wet web. The wet web is preferably thereafter pressed against the Yankee dryer while supported by the molding fabric and dried. The resulting product has exceptional wet bulk and absorbency exceeding that of conventional wet-pressed paper sheets or towels and equal to that of throughdried towels currently on the market.

Hence, in one aspect the invention resides in a method for making an absorbent paper sheet comprising: (a) depositing an aqueous suspension of papermaking fibers containing a wet strength resin onto a forming fabric which allows water to pass through while retaining fibers thereon to form a wet web; (b) dewatering the wet web to a consistency (dry weight percent fiber) of from about 10 to about 30 percent; (c) transferring the wet web to a molding fabric (hereinafter described) and substantially conforming the wet web to the surface of the molding fabric; (d) pressing the web against the surface of a heated drying cylinder, such as a Yankee dryer, to at least partially dry the web while preserving its molded structure; and (e) drying the web. The web can be partially dried on the heated drying cylinder and wet creped at a consistency of from about 25 to about 80 percent and thereafter dried (after-dried) to a consistency of about 95 percent or greater. Suitable means for after-drying include one or more cylinder dryers, such as Yankee dryers and can dryers, throughdryers, or any other commercially effective drying means. Alternatively, the molded web can be completely dried on the heated drying cylinder and dry creped. The amount of drying on the heated drying cylinder will depend on such factors as the speed of the web, the size of the dryer, the amount of moisture in the web, and the like.

In another aspect the invention resides in a wet-molded paper sheet, such as a single-ply paper kitchen towel, containing from about 0.45 to about 18.14 kg (about 1 to about 40 pounds) of wet strength resin per 909 kg (ton) of fiber, said sheet having an Absorbent Capacity of about 10 grams per gram or greater; an Absorbent Rate (hereinafter defined) of about 2.5 seconds or less; a Wipe Dry Area (hereinafter defined) of about 2500 square millimeters or less, preferably about 2300 square millimeters or less, more preferably about 2000 square millimeters or less, and suitably from about 2000 to about 2300 square millimeters or, alternatively, to about 2500 square millimeters; and a Wipe Dry Mass (hereinafter defined) of about 40 or

less, preferably about 30 or less, and suitably from about 30 to about 40. As used herein, "wet-molded" paper sheets are those which are conformed to the surface contour of a molding fabric while at a consistency of from about 10 to about 30 percent and initially thermally dried by thermal conductive drying means, such as a heated drying cylinder, as opposed to other drying means such as a throughdryer.

Suitable fibers useful for making products of this invention include any papermaking fibers, such as hardwood and softwood fibers, nonwoody fibers, synthetic fibers, and the like.

"Molding fabrics" suitable for purposes of this invention include, without limitation, those papermaking fabrics which exhibit significant open area or surface contour sufficient to impart greater z-directional deflection of the web. Such fabrics include single-layer, multi-layer, or composite permeable structures. Preferred fabrics have at least some of the following characteristics: (1) On the side of the molding fabric that is in contact with the wet web (the top side), the number of machine direction (MD) strands per centimeter (inch) (mesh) is from 3.94 to 78.74 (10 to 200) and the number of cross-machine direction (CD) strands per centimeter (inch) (count) is also from 3.94 to 78.74 (10 to 200). The strand diameter is typically smaller than 1.27 mm (0.050 inch); (2) On the top side, the distance between the highest point of the MD knuckle and the highest point of the CD knuckle is from about 0.025 mm to about 0.508 mm or 0.762 mm (about 0.001 to about 0.02 or 0.03 inch). In between these two levels, there can be knuckles formed either by MD or CD strands that give the topography a 3-dimensional hill/valley appearance which is imparted to the sheet during the wet molding step; (3) On the top side, the length of the MD knuckles is equal to or longer than the length of the CD knuckles; (4) If the fabric is made in a multi-layer construction, it is preferred that the bottom layer is of a finer mesh than the top layer so as to control the depth of web penetration and to maximize fiber retention; and (5) The fabric may be made to show certain geometric patterns that are pleasing to the eye, which typically repeat between every 2 to 50 warp yarns.

The wet strength resins that are preferred for use in connection with the present invention include those polymers that are usually used in the paper industry to provide strength to paper products when they are wetted in use. Paper products that do not contain these types of resins will quickly fall apart or lose integrity when they are wet with water. Presently, the most commonly used wet strength resins belong to the class of polymers termed polyamide-polyamine epichlorohydrin resins. There are many commercial suppliers of these types of resins including Hercules, Inc. (Kymene®), Henkel Corp. (Fibrabond®), Borden Chemical (Cascamide®), Georgia-Pacific Corp. and others. These polymers are characterized by having a polyamide backbone containing reactive crosslinking groups distributed along the backbone. Other agents that have been found useful in the present invention include wet strength agents based on formaldehyde crosslinking of polymeric resins. These are typified by the urea-formaldehyde and melamine formaldehyde-type wet strength resins. While not used as commonly as the polyamide-polyamine epichlorohydrin type resins, they are still useful in the present invention. Another class of wet strength resins found to be useful in the invention are those classed as aldehyde derivatives of polyamide resins. These are exemplified by materials marketed by American Cyanamid under the Parez® tradename as well as materials described in U.S. Patents 5,085,736; 5,088,344 and 4,981,557 issued to Procter & Gamble, which are herein incorporated by reference.

Although there are different chemical structures embodied by all of these resins, the mechanism by which they provide the effects in the present invention is essentially the same. All of the wet strength resins provide wet strength through a crosslinking reaction. This crosslinking either occurs between different portions of the resin itself, or through crosslinks with the surface of the fibers in the tissue, towel, paper or nonwoven product. The crosslinking of the resin is generally believed to prevent the water-induced disruption of the hydrogen bonds that hold the substrate together in the dry state. For a discussion of the mechanism of wet strength, see Pulp and Paper, Chemistry and Chemical Technology, Third Edition, Volume III, pages 1609-1624, James P. Casey, Editor, John Wiley & Sons, New York, 1981.

In the present invention, advantage is taken of the ability to induce the crosslinking of these resins to lock the substrate into a molded structure. In this instance it is somewhat analogous to fiber reinforced composites like fiberglass or carbon fiber composites, except that in this instance the amounts of bonding material relative to the fibrous portion of the composite are much lower. In the present invention, the effective amounts of added resin can range from about 0.45 kg (about 1 pound) of resin (dry solids) per 909 kg (ton) of fiber, up to about 18.14 kg (about 40 pounds) of resin (dry solids) per 909 kg (ton) of fiber. The exact amount of material will depend on the specific type of resin used, the type of fiber used, and the type of forming apparatus used. The preferred amounts of resin to be used are in the range of from about 2.27 kg to about 6.80 kg (about 5 to about 15 pounds) of resin per 909 kg (ton) of fiber, with a particularly preferred range of from about 3.63 kg to about 5.44 kg (about 8 to about 12 pounds) per 909 kg (ton) of fiber. These materials are typically added to the wet end of the paper machine and are absorbed onto the surface of the fiber and the fines prior to the formation of the sheet. Differences in the amounts of resin

necessary to bring about the desired effects result from different resin efficiencies, differences in the fibers and the types of contaminants that might be contained in or with the fibers (particularly important when using recycled fibers) and the ability to dry the sheet while in the molded state. It is important that the crosslinking of the resin is made to occur after the product has been molded in the wet state and before significant amounts of subsequent processing occur that might remove or reverse the molding. It has been found that once the molded structure has been formed and the resin has been fully cured to provide the final level crosslinking, the molded sheet can be deformed (either wet or dry) into another shape (flat or other pattern, such as embossments) and when the sheet is rewet, the original molded shape is reformed. This results from the reinforcement of the resin on the fibers and on the fiber/fiber bonds and provides increased bulk and Absorbent Capacity. It also enables the sheet to retain or at least substantially retain its bulk or thickness after wetting, as measured "peak-to-peak" from one side of the molded sheet to the other, even after being pressed in the wet state using finger pressure equivalent to that experienced during ordinary use. In general, the sheets of this invention will retain at least about 50% of their original dry bulk, preferably about 80 percent or more, and more preferably 90% or more, depending upon the amount of wet strength resin incorporated into the sheet. Dry bulk increases to the sheet as a result of the use of a molding fabric in accordance with this invention can be from about 10 to about 300 percent, more often from about 20 to about 100 percent relative to the bulk of a comparable unembossed wet-pressed sheet.

As used herein, "Absorbent Capacity" is the maximum amount of distilled water which a sheet can absorb, expressed as grams of water per gram of sheet. More specifically, the Absorbent Capacity of a sample sheet can be measured by cutting a 101.6 mm x 101.6 mm (4 inches x 4 inches) sample of the dry sheet and weighing it to the nearest 0.01 gram. The sample is dropped onto the surface of a room temperature distilled water bath and left in the bath for 3 minutes. The sample is then removed using tongs or tweezers and suspended vertically using a spring clamp to drain excess water. Each sample is allowed to drain for 1 minute. The sample is then placed in a weighing dish by holding the weighing dish under the sample and releasing the clamp. The wet sample is weighed to the nearest 0.01 gram. The Absorbent Capacity is the wet weight of the sample minus the dry weight (the amount of water absorbed), divided by the dry weight of the sample. Five representative samples of each product should be tested and the results averaged.

"Absorbent Rate" is the time it takes for a product to become thoroughly wetted out in distilled water. It is determined by dropping a single, 101.6 mm x 101.6 mm (4 in. x 4 in.) sample of the product onto the surface of a distilled water bath having a temperature of 30°C. The elapsed time from the moment the sample hits the water until it is completely wetted (as determined visually) is the Absorbent Rate.

The "Wipe Dry Area" and "Wipe Dry Mass" are determined by image analysis and will be fully described below. Generally, "Wipe Dry Mass" is a number approximately proportional to the mass of an aqueous residue left after a sample has been insulted with an aqueous solution. As will be hereinafter described, it is simply the product of mean optical density and area of the residue. "Wipe Dry Area" is the area coverage in square millimeters of the residue left by the sample.

Figure 1 is a schematic flow diagram of a method in accordance with this invention.

Figure 2 is a schematic diagram of the equipment used to determine the Wipe Dry Area and the Wipe Dry Mass.

Referring to Figure 1, the invention will be described in greater detail. Shown is a papermaking headbox 10 which deposits a papermaking furnish comprising an aqueous slurry or suspension of papermaking fibers and wet strength resin onto a forming fabric 11 to form a wet web 12. The forming section of the papermaking machine can include any forming configuration suitable for making towels and tissue products, including Fourdrinier formers, twin wire formers, crescent formers, and the like. While the wet strength resin is preferably added to the furnish prior to web formation, it can also be sprayed onto the wet web during or after formation. Optionally, the newly-formed web can be hydroneedled as described in U.S Patent No. 5,137,600 to Barnes et al. (1992) entitled "Hydraulically Needled Nonwoven Pulp Fiber Web", which is herein incorporated by reference. Such hydroneedling involves impingement of the newly-formed wet web with a large number of small, pressurized water jets to alter the structure of the web.

Dewatering of the web is suitably accomplished using vacuum suction by pulling a vacuum from beneath the forming fabric, or by using an optional consolidation press 13 comprising a felt 14 which is pressed against the wet web to absorb some of the moisture. Vacuum box 15 is used to maintain the web on the forming fabric and keep it from following the felt. The consistency of the wet web should be from about 10 to about 30 percent before being transferred from the forming fabric to the molding fabric 16.

Transfer of the web from the forming fabric to the molding fabric 16 is easily achieved using a vacuum suction box 17, which pulls the web onto the surface of the molding fabric and causes the wet web to conform to the surface of the molding fabric. Conformation and further dewatering of the web can be further

augmented by the use of additional vacuum boxes and/or an air press 18.

While supported by the molding fabric, the web is transferred to the surface of a heated drying cylinder such as a hooded Yankee dryer 19 with pressure roll 20. By transferring the web directly from the molding fabric to the Yankee, compression of the web is confined to the areas of the web corresponding to the knuckle points of the molding fabric. This preserves the 3-dimensional shape of the web and also minimizes the extent to which the web is pressed or compressed.

After the web is dried, it is dislodged from the Yankee by contact with a doctor blade 21 to yield an absorbent web 22 having a high degree of wet bulk.

Although not shown in Figure 1, further drying of the web using a suitable partial drying means between the suction box 17 and the pressure roll 20 can also be utilized to lessen the drying burden on the Yankee dryer 19 if desirable. Such additional drying can be achieved using a variety of drying means well known in the papermaking art, including heated cylinders, such as can dryers or a Yankee dryer, flat bed throughdryers, cylindrical throughdryers, infra-red or microwave dryers, or the like. It is preferable that the consistency of the web after the pressure roll 20 be about 40 percent or greater for ease of drying at high speeds.

Referring to Figure 2, the apparatus set-up for determining the Wipe Dry Area and the Wipe Dry Mass is illustrated. Shown is a Kreonite Macroviewer 30 (Kreonite, Inc., Wichita, Kansas) which supports two hooded flood lamps 31 and 32 (Polaroid® 4, 150 watt). A white posterboard background 33 is provided beneath the glass plates 34 which contain the residue to be quantified as described below. Also shown is a Leica/Cambridge Newvicon scanner 35 with a 35 mm. Nikon lens 36, mounted on a Polaroid ruled pole 37 with scanner fork attachment.

To measure the Wipe Dry Mass and Wipe Dry Area of a particular sheet sample, such as a paper towel, a dye solution of Marker-Blue NS dye (Keystone Aniline Corp., Chicago, Illinois) at 10.5 weight percent solids is diluted with distilled water to a solids concentration of 0.5 weight percent. The surface tension of the resulting solution is 64 dynes/cm. Five 254 x 304.8 x 3.2 mm (10 x 12 x 1/8 inch) glass plates are cleaned with "Alcojet" (Alconox, New York, New York) detergent powder and then conditioned with "Glass Plus" (Dow Brands, Indianapolis, Indiana) spray glass cleaner. An 203.2 x 203.2 x 12.7 mm (8 x 8 x 1/2 inch) aluminum plate, cut and drilled with a 12.7 mm (1/2 inch) diameter hole in its center, is placed on top of the sample to be tested. A "BD" syringe (Becton-Dickinson, Rutherford, New Jersey), without needle, is used to evenly apply the dye solution to the area of the sample exposed by the hole in the aluminum plate during a period of 2 seconds. The amount of dye applied to the sample is 3 cubic centimeters. Dye insults are made in the center of a single towel sheet rather than near an edge. After a 10 second wait, the aluminum plate and the sample are removed vertically from the glass. The wet deposit remaining on the glass is allowed to dry, which may take from about 10 to 60 minutes, depending on whether or not a drying oven is used.

The dried residue on the glass is then subjected to image analysis to determine the characteristics of the deposit and hence the absorbency effectiveness of the sample tested. The equipment set-up using a standard macroviewer with flood lamps, a white paper background and a 35 mm. Nikon lens is shown in Figure 2 and described above. A Quantimet (Leica/Cambridge, Deerfield, Illinois) image analysis program is used to interpret the residue image and calculate the Wipe Dry Mass and the Wipe Dry Area.

The image analysis program is shown below:

```
Cambridge Instruments QUANTIMET 900 QUIPS/MX V03.02
COND = 35 mm. lens; Pole = 78 cm. f/2.8; 4 floods incident
Enter specimen identity
Scanner (No. 2 Newvicon LV = 2.00 SENS = 1.65 PAUSE)
Load Shading Corrector (pattern - SCLIN1)
Calibrate User Specified (Calibration Value = 0.1425 mm. per pixel)

CALL STANDARD

TOTFIELDS  : = 0
TOTAREA    : = 0
TOTAVEBRT  : = 0
TOTDARK    : = 0
TOTMASS    : = 0

For FIELD

Detect 2D (Darker than 55 PAUSE)
Amend (OPEN by 1)
Pause Message
EDIT OUT ANY ARTIFACTS....
Edit (Pause)

Measure field - Parameters into array FIELD
Measure field - Integrated Brightness masked by Binary into array FIELD

AREA          : = FIELD AREA
AVEBRIGHT     : = (FIELD TOTBRIGHT/(AREA/(CAL.CONST. * CAL.CONST)))
DARKNESS      : = 64 - AVEBRIGHT
MASSFACT      : = AREA * DARKNESS / 1000

TOTAREA    : = TOTAREA + AREA
TOTAVEBRT  : = TOTAVEBRT + AVEBRIGHT
TOTDARK    : = TOTDARK + DARKNESS
TOTMASS    : = TOTMASS + MASSFACT
TOTFIELDS  : = TOTFIELDS + 1

Pause Message
PLEASE CHOOSE ANOTHER FIELD, or 'FINISH'...
Pause

Next FIELD

Print " "
Print "AVE TOTAL AREA (sq mm) = " ; TOTAREA/TOTFIELDS [REM: WIPE DRY AREA]
Print " "
Print "AVE MASS FACTOR = ", TOTMASS/TOTFIELDS [REM: WIPE DRY MASS]
Print " "
Print "TOTAL NUMBER OF FIELDS = ", TOTFIELDS

For LOOPCOUNT = 1 to  5
Print " "
Next

End of Program
```

Examples

Example 1: (Absorbency). In order to further illustrate the invention, different kitchen towel samples were made and compared to a commercially available throughdried kitchen towel (BOUNTY®) for a variety of properties, including absorbency and bulk.

Two-ply products of this invention were made in accordance with the method described in Figure 1. Specifically, a 50/50 softwood/hardwood blend was dispersed in a hydropulper and pumped to a stock

chest where 9.07 kg (20 pounds) of Kymene® wet strength resin per 909 kg (ton) of dry fiber was added to the furnish. The stock was deposited on a about 0.158 (94 mesh) forming fabric at a consistency of about 0.1 percent and exposed to a slight vacuum to begin drying the sheet. The sheet was transferred to an Albany 31A fabric (molding fabric) at a consistency of about 15 percent with the use of a vacuum box and molded into this fabric using a vacuum of 431.8 mm (17 inches) of mercury. (In the case of Sample 3, the amount of Kymene® added was 6.80 kg (15 pounds) per 909 kg (ton) of fiber and the speed of the 31A fabric to which the web was transferred was 5% slower than the speed of the forming fabric from which the web was transferred. For Sample 2, the fabric speeds were the same.) While supported by the 31A fabric, the molded sheet was transferred to the surface of a Yankee dryer where the sheet was dried to a 95% consistency and creped and thereafter plied together with a like sheet using a glued-nested embossing technique to form a two-ply kitchen paper towel.

The control product (Sample 1) was a conventional wet-pressed product made under the same conditions, except the molding fabric illustrated in Figure 1 was replaced with a conventional papermaking felt (Albany "bottom" felt) as is typically used for making wet-pressed paper towels.

A comparison of product properties is set forth in Table 1 below. The various properties listed in the table are expressed in the following units: Basis Weight, grams per square meter; Absorbent Capacity, grams of water per gram of fiber; Absorbent Rate, seconds; Wipe Dry Area, square millimeters; and Wipe Dry Mass, dimensionless.

TABLE 1

(Absorbency)				
Property	Sample			
	1 (Control)	2 (Invention)	3 (Invention)	4 BOUNTY®
Basis Weight	38.4	36.8	35.2	44
Absorbent Capacity	6.9	10.4	11.5	11.1
Absorbent Rate	2.9	1.9	2.3	2.2
Wipe Dry Area	2607	2054	2058	2608
Wipe Dry Mass	43.8	32.7	32.3	48.0

The results clearly show that the paper towels of this invention exhibit absorbency characteristics greater than conventional wet-pressed paper towels and equivalent to or exceeding those of a commercially available throughdried paper towel. The Absorbent Capacity exceeded 10 grams per gram for both samples of the invention. The Absorbent Rate was greatly improved over the wet-pressed control and was equal to that of the throughdried product, BOUNTY. The Wipe Dry Area and Wipe Dry Mass were significantly lower than either the wet-pressed control or the throughdried product, illustrating that less of a residue was left behind. This is obviously a desirable attribute for a paper towel.

Example 2: (Wet Bulk Retention). In order to illustrate the wet bulk or caliper retention of the products of this invention, round handsheets having a 101.6 mm (4 inch) diameter were formed on a about 0.158 (94 mesh) forming fabric using standard handsheet formation techniques. The nominal weight was 0.3 grams per sheet and otherwise identical sheets were made with and without KYMENE wet strength resin. The sheets were hand-couched using a blotter and transferred to a 5.51 x 5.51 (metric mesh/count) (14 x 14 (mesh/count)) metal wire (molding fabric). The sheets were then molded into the metal wire using a rubber-coated brass couching roll with light pressure. The wire containing the molded sheet was then placed on a steam=heated dryer to dry the sheet in the molded state. The KYMENE was allowed to cure for at least 8 hours before testing the sheets for wet caliper.

The dry caliper of the sheets was determined using a TMI model 49-70 caliper tester with a 50.8 mm (2 inch) foot and 0.08 kg per 645.2 mm^2 (0.176 pounds per square inch) pressure. As used herein, dry caliper refers to the caliper of a dry sheet as made, prior to any wetting in-use or to simulate in-use conditions. To test the sheets for wet caliper, each sheet was thoroughly wetted to simulate the water absorption associated with cleaning up a large spill. The sheet was then pressed with a finger to simulate the compressive actions common to normal usage. The sheets were then air dried and the caliper again measured with the same instrument. For purposes herein, this "simulated" wet caliper is referred to as the wet caliper of the sheet.

The results are summarized in Table 2 below. "Weight" is expressed in grams; "Initial Caliper" is the dry caliper prior to wetting, expressed in millimeters (inches); and "Final Caliper" is the caliper after wetting,

compression, and drying, expressed in millimeters (inches).

TABLE 2

(Wet Bulk Retention)				
	Sample 1	Sample 2	Sample 3	Sample 4
KYMENE	No	Yes	No	Yes
Weight	0.290	0.304	0.313	0.300
Initial Caliper	0.386 (0.0152)	0.399 (0.0157)	0.409 (0.0161)	0.439 (0.0173)
Final Caliper	0.241 (0.0095)	0.396 (0.0156)	0.310 (0.0122)	0.419 (0.0165)
Percent Caliper Retained	62.5	99.4	75.8	95.4

The results clearly show the substantially improved bulk or caliper retention exhibited by Samples 2 and 4 of this invention, which contained a wet strength resin, compared to that of Samples 1 and 3, which did not contain a wet strength resin. Wet bulk retention is complimentary to the absorbent properties also exhibited by the products of this invention, providing very desirable basesheet properties for paper towels and other absorbent sheet products.

In addition, for purposes of further comparison, an unmolded handsheet sample weighing 0.295 grams was prepared in the same manner as described above. The sample had an initial dry caliper of 0.233 mm (0.0092 inch) and, after wetting, pressing and drying again, a final caliper of 0.233 mm (0.0092 inch). This illustrates the substantial increase in dry caliper imparted to the sheet by wet molding when compared to an ordinary wet-pressed sheet.

Example 3: (Wet Bulk Retention- Conventional Embossed Towels). In order to illustrate the benefits of this invention relative to conventional wet-pressed sheets which have been embossed, 101.6 mm (four inch) diameter circular samples were cut out of a commercially available two-ply paper towel which had been made with a conventional wet-pressing process and thereafter embossed with an overall "random dot" embossing pattern. The furnish contained KYMENE wet strength resin. The circular samples were separated into single plies and tested as described above. The results are summarized in TABLE 3 below:

TABLE 3

(Wet Bulk Retention: Conventional Wet-Pressed/Embossed)				
	Sample 1	Sample 2	Sample 3	Sample 4
KYMENE	Yes	Yes	Yes	Yes
Weight	0.132	0.133	0.139	0.137
Initial Caliper	0.376 (0.0148)	0.480 (0.0189)	0.429 (0.0169)	0.444 (0.0175)
Final Caliper	0.190 (0.0075)	0.180 (0.0071)	0.190 (0.0075)	0.173 (0.0068)
Percent Caliper Retained	51	38	44	39

The samples of this example retained so little bulk relative to Samples 2 and 4 of TABLE 2 because the wet-pressed samples of this example were not wet-molded. Although the caliper was increased by embossing, the increased caliper was not retained when the sheet was wetted and subjected to slight finger pressure.

Example 4: (Conventional/Embossed vs. Invention/Embossed) A standard wet-pressed basesheet (Control) and a wet-molded basesheet in accordance with this invention were made as described in Example 1, except the basesheets were combined into a two-ply sheet and embossed as described in Example 3. Both samples were tested as a two-ply product for wet bulk retention as described in Example 3. The results are summarized in TABLE 4 below:

TABLE 4

(Conventional/Embossed vs Invention/Embossed)		
	Control	Invention
KYMENE	Yes	Yes
Weight	0.320	0.272
Initial Caliper	0.439 (0.0173)	0.513 (0.0202)
Final Caliper	0.229 (0.0090)	0.373 (0.0147)
Percent Caliper Retained	52	73

The Control sample was a two-ply analog of the samples of Example 3 and showed similar results in that, in both cases, the high initial dry caliper was due to the embossing pattern developed during converting of the basesheet. The wet-molded sample of this invention was similarly converted, but retained more caliper after wetting/pressing because the portion of the caliper due to the wet molding was not lost when wetted/pressed. In both cases the caliper due to embossing was lost.

Example 5: (Calendared Sheets). A handsheet weighing 0.279 grams and containing KYMENE was made and molded as described in Example 2. The sheet was calendared between two steel rolls and the resulting caliper (Initial Caliper) was measured to be 0.213 mm (0.0084 inch). The wet caliper (Final Caliper) of the calendared sheet was also determined as described in Example 2, which was measured to be 0.315 mm (0.0124 inch). The percent increase in caliper resulting from wetting was 48 percent. Hence the wet-molded sheet retains its memory during calendaring, resulting in a wet caliper: dry caliper ratio of greater than 1. The extent to which the ratio exceeds 1 depends upon the 3-dimensionality of the molding fabric and the severity of the calendaring. Molding fabrics with high hills and low valleys will produce sheets with very high dry bulks. Combined with heavy calendaring, such sheets can have wet caliper:dry caliper ratios of about 2 or greater. Typically, the wet caliper:dry caliper ratio will be from about 1.2 to about 2, more specifically from about 1.5 to about 2. Such sheet behavior is advantageous for use in paper towels, for which low dry bulk and high wet bulk can be a very desirable combination.

Claims

1. A paper sheet containing from 0.45 to 9.07 kg (1 to 20 pounds) of wet strength resin per 909 kg (ton) of fiber, said sheet having an Absorbent Capacity of about 10 grams per gram or greater, an Absorbent Rate of 2.5 seconds or less, a Wipe Dry Area of 2500 square millimeters or less, and a Wipe Dry Mass of 40 or less.

2. The paper sheet of Claim 1 having a Wipe Dry Mass of from 30 to 40.

3. The paper sheet of Claim 1 or 2 having a Wipe Dry Mass of about 35 or less.

4. The paper sheet of any one of the preceding Claims wherein the Wipe Dry Area is from 2000 to 2500 square millimeters.

5. The paper sheet of any of the preceding Claims wherein the Wipe Dry Area is about 2000 square millimeters or less.

6. The paper sheet of any one of the preceding Claims having a wet caliper of at least 80 percent of its dry caliper as measured in an unembossed state preferably of at least about 90 percent of its dry caliper as measured in an unembossed state.

7. A paper towel having a wet caliper:dry caliper ratio of 1.2 or greater preferably of from 1.2 to 2 and more preferable of from 1.5 to 2.

8. The paper towel of Claim 7 comprising a paper as per any one of Claims 1 to 6.

9. A method for making an absorbent paper sheet comprising:

(a) depositing an aqueous suspension of papermaking fibers containing a wet strength resin onto a forming fabric which allows water to pass through while retaining fibers thereon to form a wet web;
(b) dewatering the wet web to a consistency of from 10 to 30 percent;
(c) transferring the dewatered web to a molding fabric and substantially conforming the wet web to the surface of the molding fabric;
(d) pressing the molded web against the surface of a heated drying cylinder to at least partially dry the web while preserving the molded structure; and
(e) drying the web.

10. The method of Claim 9 wherein the web is partially dried to a consistency of from 25 to 80 percent on the surface of the heated drying cylinder, wet creped, and thereafter final dried to a consistency of 95 percent or greater.

11. The method of Claim 10 wherein the wet creped web is final dried by passing over one or more can dryers.

12. The method of any one of Claims 9 to 11 wherein the molded web is dried to 95 percent consistency or more and thereafter creped.

13. The method of any one of Claims 9 to 12 wherein the amount of wet strength resin in the aqueous suspension of papermaking fibers is from 0.45 to 18.1 kg (1 to 40 pounds) per 909 kg (ton) of fiber.

14. The method of Claim 13 wherein the amount of wet strength resin in the aqueous suspension of papermaking fibers is from 2.3 to 6.8 kg (5 to 15 pounds) per 909 kg (ton) of fiber preferably from 3.6 kg to 5.4 kg (8 to 12 pounds) per 909 kg (ton) of fiber.

15. The method of any one of Claims 9 to 14 wherein the wet web is dewatered to a consistency of from 10 to 30 percent using press felt prior to being transferred to the molding fabric.

16. The method of any one of Claims 9 to 15 wherein the wet web is substantially conformed to the surface of the molding fabric by transferring the wet web from the forming fabric to the molding fabric with a vacuum of from 254 to 711 mm (10 to 28 inches) of mercury.

17. The method of any one of Claims 9 to 16 wherein conformation of the web to the molding fabric is enhanced by an air press which blows air against the web while supported by the molding fabric.

18. The method of any one of Claims 9 to 17 wherein the wet web is pressed against the heated drying cylinder while remaining in contact with the molding fabric.

19. The method of any one of claims 9 to 18 wherein the molded web is pressed against the surface of a heated drying cylinder at a consistency of from 30 to 40 percent and drying the web and creping the dried web to form a paper sheet having an Absorbent Capacity of 10 grams per gram or greater, and/or a Wipe Dry Area of 2500 square millimeters or less, and/or a Wipe Dry Mass of 40 or less.

20. An absorbent paper sheet especially according to any one of claims 1 to 6 obtainable by the method of any one of Claims 9 to 19.

21. A paper towel especially according to claim 7 or 8 obtainable by making an absorbent paper according to any one of claims 9 to 19.

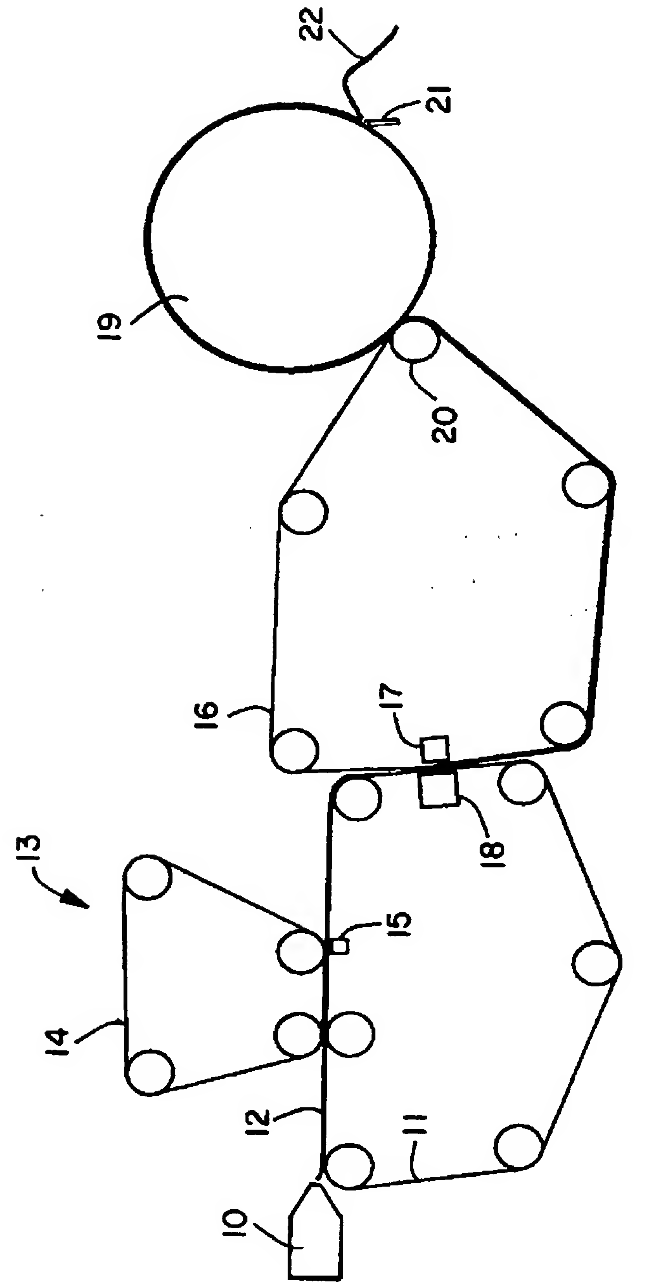

FIG. I

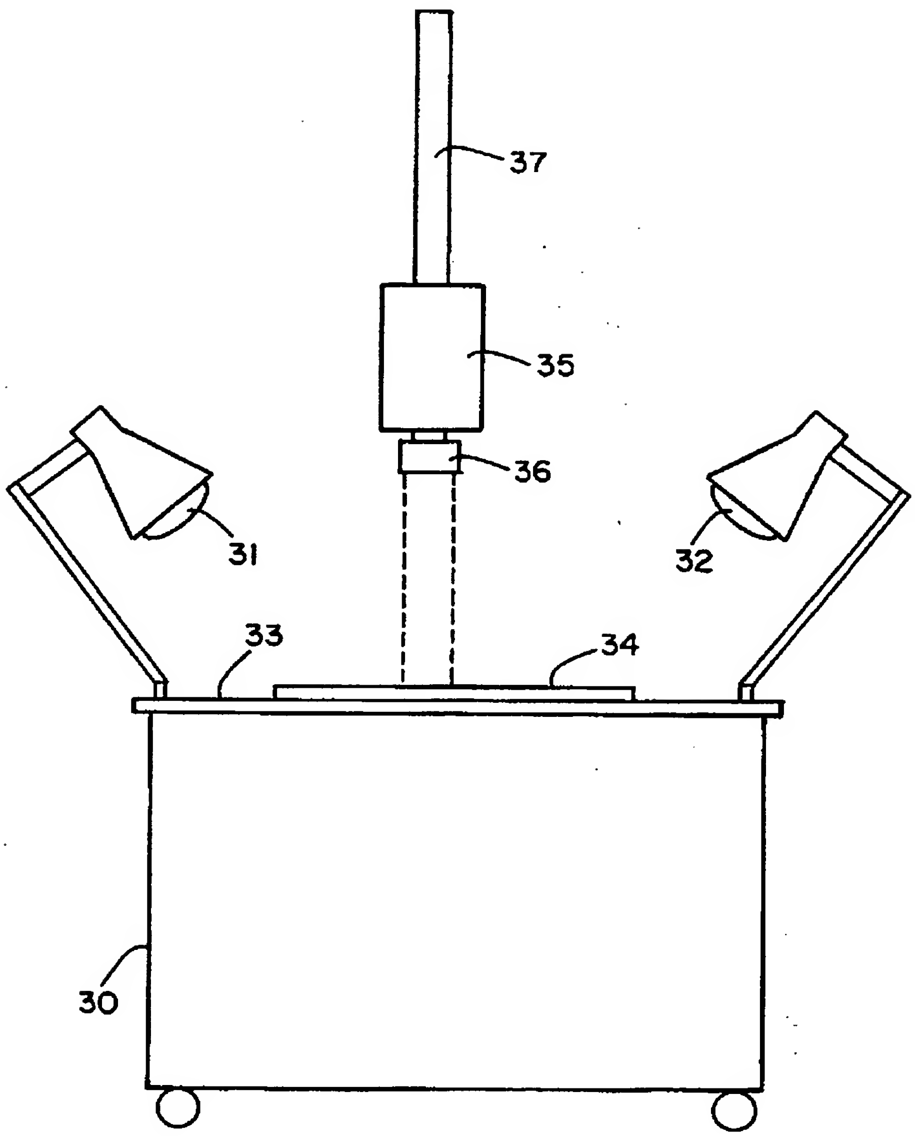

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 4326

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	EP-A-0 140 404 (THE PROCTOR & GAMBLE CIE) * the whole document * ---	9,12	D21F11/00
A	US-A-4 225 382 (KEARNEY ET AL) * the whole document * ---	9,12	
A	US-A-3 755 220 (FREIMARK ET AL) * the whole document * -----	9	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

D21F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 June 1994	De Rijck, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)